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## REPORT DOCUMENTATION PAGE

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13. ABSTRACT (Maximum 200 words)		
<p>This equipment grant has provided for the purchase of photometric equipment and accessories required to conduct studies on the effect of illuminance on human cognitive and motor performance. Joint studies conducted with scientists at USAFSAM and the University of Pennsylvania utilized this equipment. Six other projects at Northern Arizona University are also utilizing these items of equipment.</p>		
		
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1990 USAF FINAL TECHNICAL REPORT

Sponsored by the

AIR FORCE OFFICE OF SCIENTIFIC RESEARCH  
AFOSR-89-0164

FINAL TECHNICAL REPORT

HUMAN COGNITIVE AND MOTOR PERFORMANCE MEASURES UNDER TYPICAL COOL  
WHITE FLUORESCENT ILLUMINATION VS RELATIVELY HIGH COOL WHITE  
ILLUMINANCE/IRRADIANCE LIGHTING

Prepared by: Patrick Roy Hannon, Ed. D.

Academic Rank: Associate Professor

Department/University: Department of Health, Physical  
Education and Recreation  
School of Health Professions  
Northern Arizona University

Date: 31 January 1990

Final Technical Report for Period 1-December 1988 - 30  
December 1989

Prepared for:  
Dr. William Berry  
AFOSR/NL  
Building 410  
Bolling AFB DC 20332-6448

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### List of Equipment Purchased

Grant # AFOSR-89-0164

Radiometer/Photometer, Radiometric probe and illuminance probe includes calibration).....\$2,659.38

Revco Ultra Low Temperature with accessories.....\$5,984.34

Model #112 Sequoia Turner Fluorometer.....\$5,159.59  
Accessories (filter set).....\$610.32

High Capacity Table Top Refrigerated Centrifuge with TH-rotor - Model TJ-6R.....\$5,383.12

Watsmart Real Time Board with 3-Dimensional Rigid Body Program, 12 inch calibration cube, and upgrades on circuit boards for 3 Infrared Cameras....\$13,710.00

Total.....\$33,506.75

\*Please see the Equipment Account #350810 with the listing of POs, dates, etc.

### Additional Equipment Purchased As Per Permission Dr. Berry:

PO #138577	Run Technologies	#S001.2 - Supervisor Package #M001.2 - Data File Management #A020.2 - Waveform Procession #A023.2 - PSA	Total	\$ 454.25
PO #138578	MEI Micro Center	BASF High Density Disks (10)	Total	\$ 53.39
PO #138579	Grass Instrument	E5GH Electrodes EC 2 Electrode Cream (10 tubes)	Total	\$ 89.25
PO #138580	D.O. Weaver & Co.	Bottles (7)	Total	\$ 37.85

Additional costs were incurred for shipping, etc.

TOTAL \$34,236.00

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Availability Notes
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## Summary of Research Efforts

### HUMAN COGNITIVE AND MOTOR PERFORMANCE MEASURES UNDER TYPICAL COOL WHITE FLUORESCENT ILLUMINATION VS RELATIVELY HIGH COOL WHITE ILLUMINANCE/IRRADIANCE LIGHTING

Phase I- Baseline data- collected Spring, 1989 at the Biomechanics/Motor Control Laboratory at Northern Arizona University

This study was undertaken to investigate possible practice effects and diurnal fluctuations in human motor and cognitive performances under baseline illumination conditions (400 lux).

Six subjects were tested individually in order to partial out peer social interaction effects. The testing took place over a wide range of testing time epochs. Specifically, subjects were tested from 0800 to 1200 hours, 1400 to 1800 hours and 2000 to 0000 hours in a counter-balanced repeated measures design,

#### Keywords: Test AND EVALUATION, Test Equipment.(Eg)

Reaction time measures over several trials each session failed to reveal any significant differences for time of day,  $F = .584$  or for order effect,  $F = 2.27$ . The subjects' performances were nearly identical during the morning, afternoon, and evening sessions with subjects stabilizing their performance relatively early during the first testing session. Similarly, multiple choice reaction time data revealed neither a time of day ( $F = .994$ ) or an order effect ( $F = .343$ ). Typing performance is reported in terms of the number of words minus the number of errors. No significant differences were found in terms of time of day ( $F = 1.03$ ) or order effect ( $F = .594$ ). In contrast to the above findings, pursuit rotor performance data revealed strong practice effects. At 30 revolutions/minute, all 3 time periods were significantly different from one another in the predicted direction of second and third testing periods indicating continued improvement ( $F = 59.83$ ,  $p = .0001$ ) (Scheffe F follow-up test). At 60 revolutions/minute, a practice effect occurred between the second and third session, ( $t = 3.44$ ,  $p = .02$ ). Finally, advanced flight simulator testing did not reveal any time of day or order of presentation effects. Subjects were performing at a high level of mastery (roughly 90% accuracy) early within the first testing session. The more complex computer role playing task (Tracon) did show a diurnal effect. Interestingly, the subjects took more time to complete the task of landing 5 aircraft during the afternoon session than they did during the evening session ( $t = 2.94$ ,  $p = .05$ ). An order of presentation effect for Tracon performance indicated that a significant improvement between the first and third sessions occurred with subjects performing better during their last performance period ( $F = 5.27$ ,  $p = .02$ ). The percent accuracy score data from Tracon indicated an order of presentation difference favoring the third testing session over the first ( $t = 8.92$ ,  $p = .0003$  and the second ( $t = 3.069$ ,  $p = .02$ ),

indicating that this measure did not stabilize during the three 4 hour sessions.

#### Cognitive and Affective Measures

Results for the Digit Symbol Substitution Task indicate that there were only significant order of presentation effects for all 3 test presentations in the predicted direction ( $F = 45.14$ ,  $p = .0001$ ). There was a significant degree of improvement from the first to the second task, and this continued from the second to the third test presentation, as revealed by a Scheffe F test for separate group comparisons.

The Profile of Moods States served as a measure of vigor, fatigue/inertia and tension. No significant differences were found for the time of day or order of presentation effects. This result leads the investigators to conclude that the 4 hour testing period was too short to induce a fatigue state. Further, perhaps the high degree of subject motivation attenuated any feelings of fatigue that would normally be present during a late evening time frame. In turn this maintained vigor, alertness, etc. may well have resulted in the consistent time of day performances indicated by the present investigators' results.

#### Discussion

The above results indicate the difficulty in measuring cognitive performance, alertness and human motivation. Clearly, many of the measures did not stabilize with the limited practice provided to subjects. Further, subject alertness and concomitant performance measures did not in this present research indicate fatigue degradation. It seems that a sustained work performance of long duration and through a circadian cycle low alertness time frame may be the best way to examine the effect of a variety of experimental variables including illumination effects. Further, cognitive and motor tests must be used which are sensitive to fatigue degradation. The tests that make up the UTC-PAB have this potential. Electrophysiological and blood hormone measures also have the potential to provide solid dependent measures in this line of research. Phase II incorporated these measures.

The Phase I research effort is in the final writing stages and this work will be submitted to Perceptual Motor Skills Journal in late Feb., 1990.

## Phase II

Phase II data was collected at Brooks AFB -Summer, 1989.

Effects of Bright Illuminance on Human Performance and Body Temperature. J. French, P. Hannon and G. Brainard. USAF School of Aerospace Medicine Brooks AFB, Tx

### Summary

Plasma levels of the pineal hormone melatonin are greatest during the sleep phase of the vertebrate circadian cycle. Orally administered melatonin is associated with sleepiness and increased measures of fatigue (1,2). Recently, it has been shown that melatonin levels can be acutely suppressed by bright, white light in mammals including man. If increased light intensity can suppress the levels of circulating melatonin, then it may attenuate fatigue degraded performance. The objective of this project was to assess the effects of bright illumination on plasma melatonin and to determine if this treatment could reduce fatigue and enhance performance. A counter-balanced, within subjects analysis of variance design was used to compare 9 male subjects exposed to dim (100 lux) and bright (3000 lux) conditions. Subjects were recruited from non-smoking civilian and military personnel who indicated a normal nocturnal sleep pattern and passed a test subject physical. During both conditions, scores on cognitive performance tests developed for military human performance labs (3) were obtained every 2 hours throughout the 29 hour testing session. Beginning at 0700, subjects practiced the performance measures under dim light training conditions. Then at 1800, the light treatment (either dim or bright) began and lasted until 0800 the next day. Immediately after each performance trial, oral temperature was measured and plasma and saliva samples were obtained for later melatonin and cortisol assays. Subjects were allowed 2 weeks before exposure to the second light condition. Oral temperature levels were significantly elevated in the bright light group compared to the dim light condition at the 2130, 0130 and the 0330 sample points ( $p < .05$ ). Analyses of performance data indicate that bright light treatment improved response time while reducing the number of errors, particularly at the 2400 through the 0400 sample points. Some practical applications of these findings suggest that bright lights may be used to heighten the level of alertness and improve performance otherwise susceptible to fatigue, particularly during early morning shifts.

1. Wurtman, R.J., et al., Integr. Psychi., 1987, 5, 3-26.
2. Anton-Tay, F., et al., Life Sci., 1971, 10, 841-850.
3. Thorne, D.R., et al., Neurobeh. Tox. and Teratol., 1985, 7, 415-418.

Key Words: Fatigue, Illuminance, Performance, Temperature

\*See the attached Universal Energy Systems Summer, 1989 Fellowship report for a complete description of this research effort.

## Other Research Work of Interest to the Dept. of Defense

These research efforts are in-progress and are taking place under the direction of one of the co-investigators of the present DURIP Grant.

Dr. David Arnall

1. Equipment used:      Refrigerated Centrifuge  
                              Ultralow Temperature Freezer

Project: The Effects of Fasting on Myocardial Substrates in Cardiac Tissue

This project is examining the effects of 0, 1, 2 and 3 days of fasting on the endogenous lipid pools in the heart. Monoglycerides, diglycerides and triglycerides will be measured as well as endogenous (intracellular) free fatty acids. Blood metabolites will be assayed such as glycerol, glucose, lactate as well as tissue glycogen.

The purpose of this study is to measure how labile the endogenous fat stores are during the fasted condition in cardiac tissue. Project is just beginning.

2. Equipment used:      Refrigerated Centrifuge  
                              Ultralow Temperature Freezer

Project: The Effects of Fasting and Exhaustive Exercise on the Indirect Pathway in Gluconeogenesis

This project examines the pathways - both direct and indirect gluconeogenic pathways - by which carbohydrates are taken up into the liver and muscle cells. Project is underway.

3. Equipment used:      Refrigerated Centrifuge  
                              Ultralow Temperature Freezer

Project: The Effects of Ingesting Glycerol on the Body Water Retention and the Maintenance of Urine and Blood Electrolytes in U.S. Navy Special Warfare Divers (SEALS)

This project is designed to evaluate the effectiveness of ingesting glycerol in an attempt to reduce diuresis and loss of electrolytes secondary to prolonged underwater immersion in 10 C water. Project is near completion.

4. Equipment used:      Refrigerated Centrifuge  
                              Ultralow Temperature Freezer

Project: The Metabolic Consequences of Exercise in Cold Water by Cold Adapted and Non-Cold Adapted Rats.

This project examines the protective metabolic consequences of cold adaptation during an exercise bout in the cold compared to the exercise responses in non-cold adapted rats. Project underway.

5. Equipment used: Refrigerated Centrifuge  
Ultralow Temperature Freezer

**Project: The Effects of Iontophoretically Driven Dexamethasone on Intracellular Metabolism in the Skeletal Muscle of Sprague-Dawley Rats**

This project is designed to evaluate the effectiveness of driving dexamethasone (an anti inflammatory agent - a synthetic glucocorticoid) iontophoretically into skeletal muscle tissue and determining how dexamethasone effects local muscle metabolism. Project is underway.

## In Progress - McPoil and Cornwall

## KINEMATIC ANALYSIS OF THE LOWER EXTREMITY DURING CYCLING

**Principle Investigators:** Tom McPoil, PhD, PT  
Mark Cornwall, PhD, PT

The purpose of this study was to examine the effect of restricted vs. unrestricted foot rotation, during the cycling motion, on the movement patterns of the thigh and lower leg. Ten volunteers, two females and 8 males, with mean age of 24.8 years served as subjects. The procedure for the study involved placing the subject's bike on a stationary roller system with the front fork of the bike placed on a static stand to prevent loss of balance during data collection. Next, the subject's left pedal was removed and a special pedal, permitting foot rotation during pedaling, was attached. The WATSMART Motion Analysis system was used for data collection. Each subject pedaled their bike for the following three conditions: no rotation, 10 degrees of rotation, and 20 degrees of rotation. The WATSMART Rigid Body Analysis Software Package was used for data analyses, to determine yaw, pitch, and roll, of the thigh and lower leg segments.